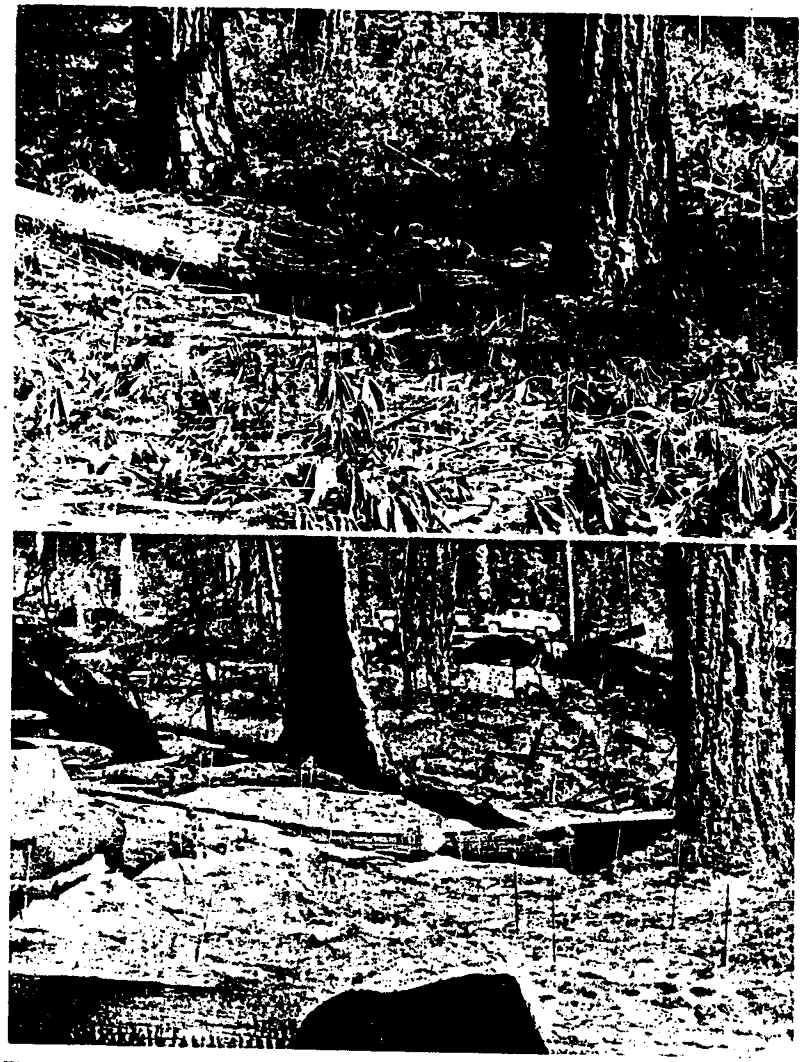

Fig. 1. One of the 25 experimental blocks before and after slash burning illustrates the nearly complete consumption of above-ground plant parts by fire. Steel reinforcing bars evident in the post-burning photo mark the corners of the nine experimental treatments. Photo by Charles Halpern.

early-, mid-, and late-summer for five or more growing seasons. We will compare changes in species composition and three components of species diversity—richness, heterogeneity, and evenness (based on percent canopy cover, stem density, and total above-ground biomass)—among treatment and control plots.

Silvicultural research in Douglas-fir forests has tended to focus on the growth responses of commercial tree species to competition from invasive or residual vegetation. In contrast, our study will be the first in these forests to examine how whole plant communities and related soil characteristics respond to altered competitive regimes. Knowledge of the factors that control changes in plant species diversity is essential to understanding the complex responses of natural and managed ecosystems to large-scale disturbance.

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Changes in Plant Species Diversity after Harvest of Douglas-fir Forests

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Clearcut logging and slash burning have been major agents of disturbance in forests of the Pacific Northwest since the early 1900s. Like their natural counterparts—windstorms and wildfires—these human-caused disturbances profoundly alter forest structure and function, eliminating tree canopies, releasing stores of carbon and nutrients, and modifying levels of biodiversity.

We are studying the effects of logging and burning on the diversity of plant species in Douglas-fir forests of the western Cascade Range. In particular, we are interested in how colonizing (invading) and surviving species influence long-term patterns of diversity. We have been addressing these questions by studying permanent plots on three experimental watersheds (WS1, WS3, and WS10) of the Andrews Experimental Forest, Oregon (Dyrness 1973; Halpern 1988, 1989; Halpern and Franklin 1990).

Initial losses of plant species due to harvesting may be dramatic. On site WS3, 29% of original forest species were absent one year after logging. However, our results also suggest that this loss of diversity is short-lived. Within 2–5 years after burning of WS1 and WS3, species richness (total number of taxa) and species heterogeneity (a measure of richness weighted by the relative abundances of species) returned to, or exceeded, pre-disturbance levels. This rapid recovery of both measures of diversity reflects (1) early invasion of disturbed sites by many wind-dispersed colonists; (2) immediate resprouting of original forest species; and (3) reduced dominance of the initially most abundant taxa.

After 14–24 years, species richness remained high on all three sites, exceeding the richness of original old-growth forests by 50–90%. More than 90% of original old-growth species were also present. In addition, numerous European or Eurasian "aliens"—now ubiquitous members of the regional flora—recruited and persisted. Ultimately, as tree canopies begin to close, richness will decline sharply as shade-intolerant colonists are eliminated. Despite these long-term increases in richness, 4–7% of original forest species (fairly uncommon, fire-sensitive herbs in the families Ericaceae and Orchidaceae) were lost from the sample plots.

Nevertheless, judging effects based simply on the number of species can be somewhat misleading. Apparent long-term increases in diversity following forest harvest disappear if other measures of diversity, such as species heterogeneity, are used. Heterogeneity has declined to pre-disturbance levels prior to canopy closure as initial understory species have resumed their dominance (Halpern 1988, 1989). Thus, our study illustrates that the consequences of forest harvest for biodiversity are complex. Although the understory vegetation is largely resilient, some taxa become locally extinct, and many invaders may persist at low abundance until the tree canopy closes.

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Tree Establishment in Canopy Openings in Mature Douglas-fir Forests

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Biological diversity in coastal Douglas-fir forests is strongly associated with forest age and the arrangement of older forests on the landscape. Many plant and animal species first appear late in succession as these forests develop the multi-layered and patchy canopies characteristic of old growth. It is presently unknown whether this influx of species is in response to a general decline in the dominance of the large Douglas-fir (*Pseudotsuga menziesii*), or to discrete openings in the forest canopy (termed "canopy gaps") caused by the death of large trees. The answer is important for maintaining ecological diversity in managed forests and reserves.

The objective of our research is to determine how the establishment of tree seedlings is affected by the environmental and vegetative changes caused by canopy gaps in Douglas-fir forests. The abundance of light and moisture available for young seedlings varies due to the size of the canopy gap as well as the position within a gap. For example, large gaps have more light and soil moisture than small gaps, and the northern edges of gaps receive more light than the southern edges. Patterns of resource abundance are further